4-D Current Experiment Using AUV and HF-Radar

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LONG TERM GOALS

The goal of the proposed study is to understand the role of small-scale physical processes in the coastal ocean through observations of the four-dimensional current variability. The approach combines the Florida Atlantic University Autonomous Underwater Vehicle (AUV) technology with the RSMAS Ocean Surface Current Radar (OSCR). The engineering part of the proposed research seeks to develop, integrate and test instrumentation designed to measure and characterize the subsurface current structure from AUVs. The working scientific hypothesis is that subsurface and surface currents are dynamically linked through the internal wave continuum such that the four-dimensional physical environment can be reconstructed by integrating AUV, OSCR, shipboard and moored observations. In terms of fluid dynamics, the scientific part of this investigation relates observed current patterns induced by winds (Ekman), low-frequency flows and tides to internal waves in a regime with variable stratification and bottom topography.

OBJECTIVES

Specific engineering and scientific objectives are:

- To design and implement multiple ADCPs as part of the AUV payload;
- To evaluate side-looking ADCP beam orientations with respect to minimizing surface and bottom echo interference;
- To relate the aerial estimates of the OSCR-derived surface currents in selected cells to high-resolution subsurface current measurements acquired from ADCPs on multiple AUVs as well as from ship- and mooring-based (*i.e.* Cyclesonde) observations;

- To isolate low-frequency (subinertial), wind-driven (Ekman), tidal and internal wave signals present in the surface current signals, and to relate them to the vertical structure of subsurface currents and stratification observed by AUVs, ships and moorings;

- To assess the role of divergence and vorticity fields associated with subinertial and wind-driven flows and their net impact on submesoscale dynamics; and

- To relate the internal wave field to acoustic properties of the water column.

APPROACH

The RSMAS OSCR radar system (VHF mode) will be deployed in early 1999 at the South Florida Ocean Measurement Center (SFOMC) to measure the surface current field. Concurrently, subsurface current and density data will be acquired over a 30-day period with multiple ADCP and CTD probes on the FAU Ocean Explorer AUV, on a research vessel, and on a subsurface Cyclesonde mooring. The AUV will provide horizontal/vertical flow measurements around a mooring at the highest spatial resolution, and hence the smallest scales over a 2 *km* x 2 *km* grid embedded within a 4 *km* x 4 *km* grid for the shipboard measurements (Smith *et al.*, 1998). Surface current data provide spatial context for all observations including a mooring time series of current and stratification at a central site over a 5 *km* x 11 *km* grid with 250 *m* spacing between the surface current measurements. Initially, we plan on ship/AUV surveys in two boxes in shallow and deeper water, one including the mooring location. When OSCR detects flow processes of special interest, e.g. fronts, ship and AUV-based sampling will be redirected to their locations. In addition, a third grid will be conducted in just one OSCR cell to examine the aerial average over an OSCR cell to the high-resolution ADCP transects from multiple AUVs. Such measurements will also address the dependence of the measurements between adjacent cells and the down-radial spreading function.

TASKS COMPLETED

Completed a preliminary analysis of the AUV-derived currents from the 5 and 11 Dec 1997 in the vicinity of the shallow water Acoustic Doppler Current Profiler at the mouth of Port Everglades in support of the NICOP project at FAU.

RESULTS

Measurements of bathymetry, current and CTD measurements were acquired in shallow water on 5 and 11 Dec 97 in a *lawn-mower* pattern (An *et al.*, 1998). These surveys were conducted over about a 3 h period at a constant water depth of 7 m in the vicinity of an ADCP. On 5 Dec 97, this area was influenced by the passage of a weak cold front where winds approached 10 m s^{-1}. The moored ADCP indicated wave activity with periods of about 4 h and barotropic tidal currents were aligned in the along-shelf direction with amplitudes of about 5-7 cm s^{-1}. The AUV derived current field also revealed wave-like activity, and the Doppler Velocity Logger also provided a high-resolution map of the bottom terrain between two reef tracks.

IMPACT

The anticipated impact of such an approach will be useful for the Navy Fleet operating in the littoral zones, requiring adaptive sampling strategies to conduct training exercises (i.e. NAVOCEANO). In addition, fine-scale measurements will provide the operational models with high-quality observations to assess model performance in the littoral zone.

TRANSITIONS

The approach of using HF radars with high-resolution AUVs deployed in an adaptive sampling strategy should eventually be transitioned to the US Naval Fleet for operations.

RELATIONSHIP TO OTHER PROJECTS

The basic and applied research described herein is relevant to several programs within ONR and to operational and tactical Navy communities including the Naval Research Laboratories where high-resolution models are under development and evaluation.

REFERENCES

Smith, S., E. An, J. Park, L. K. Shay, H. Peters, and J. VanLeer, 1998: Submesoscale coastal ocean dynamics using autonomous underwater vehicles and HF radar. *2nd Conference on Coastal Atmospheric and Oceanic Prediction*, 11-16 January 1998, Phoenix, AZ, American Meteorological Society, 143-150.

PUBLICATIONS (NEW START)

An, E., M. Dhanak, L. K. Shay, and J. VanLeer, 1998: Coastal oceanography using a small AUV, *J. Atmos. Oceanogr. Tech.* (submitted)